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FULL PLATE, ALTERNATING LAYERED REFRIGERANT FLOW EVAPORATOR

TECHNICAL FIELD

[0001] The invention relates to a heat exchanger, and, more particularly, the invention relates to an evaporator for a climate control system of a motor vehicle.

BACKGROUND OF THE INVENTION

[0002] Despite advances in the design of automotive heat exchangers, the pressure is still strong for continued improvements, even in the face of demands for cost reductions. For evaporators, there are multiple needs, two of which are to reduce size and mass. Accomplishing this is a real challenge, since the cooling capacity and temperature uniformity should not be substantially compromised. Some designs presently in production accomplish this through increased complexity such as a multi-tank construction, adding fins on the refrigerant side, or manifold designs that utilize various sized orifices. Other designs presently in production use two-row extruded tube and center construction. While these designs have facilitated smaller heat exchanger design, the added complexity has increased the cost of producing the heat exchanger.

SUMMARY OF THE INVENTION

[0003] The present invention provides a method for manufacturing an evaporator including the step of connecting two similar plates in a back-to-back, mirrored relationship to form a first pair of plates. The method also includes the step of connecting another two plates in a back-to-back, mirrored relationship to form a second pair of plates. The plates that form the first pair are different than the plates that form the second pair. The method also includes stacking the pairs of plates together.

[0004] The plates include apertures that are aligned when the plates are connected in pairs and stacked together. The plates also include mounds formed around various apertures. The structural cooperation between the plates, the apertures in the plates, and the mounds form pathways for directing movement of a fluid stream. The fluid stream, such as a stream of fluid to be evaporated, can be directed in alternating directions in adjacent pathways.

[0005] Other applications of the present invention will become apparent to those skilled in the art when the following description of the best mode contemplated for practicing the invention is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein;

[0007] Figure 1 is a perspective view of an evaporator according to an embodiment of the invention;

[0008] Figure 2 is a perspective view of a first plate according to the invention;

[0009] Figure 3 is a enlarged view from Figure 2 of a first end of the first plate;

[0010] Figure 4 is a perspective view of a second plate according to the invention;

[0011] Figure 5 is enlarged view from Figure 4 of a first end of the second plate;

[0012] Figure 6 is a perspective, staggered cross-sectional view of the evaporator shown in Figure 1, the cross section taken along an inlet manifold of the evaporator;

[0013] Figure 7 is a side view of the cross-sectional view of Figure 6;

[0014] Figure 8 is a perspective, staggered cross-sectional view of the evaporator shown in Figure 1, the cross-section taken along the outlet manifold;

[0015] Figure 9 is a side view of the cross-sectional view of Figure 8;

[0016] Figure 10 is a perspective, partial cross-sectional view of the evaporator of Figure 1 taken along the return tank;

[0017] Figure 11 is a side view of the cross-sectional view of Figure 10;

[0018] Figure 12 is a perspective, broken cross-sectional view of the evaporator of Figure 1 extending along the length of the evaporator;

[0019] Figure 13 is a side view of the cross-sectional view of Figure 12;

[0020] Figure 14 is a perspective view of an alternate embodiment of a first plate;

[0021] Figure 15 is an enlarged view from Figure 14 of a first end of the alternative first plate;

[0022] Figure 16 is a perspective view of an alternative embodiment of the second plate;

[0023] Figure 17 is an enlarged view from Figure 16 of a first end of the alternative second plate; and

[0024] Figure 18 is a cross-sectional view of an embodiment of the invention showing fluid pathways arranged in an alternating pattern.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Various embodiments of the invention are shown throughout the several figures. Similar structure can be defined by alternative embodiments of the invention. Similar structural elements share a common reference numeral and are differentiated with an alphabetic designation.

[0026] Referring now to Figure 1, the present invention provides an evaporator 10 including two first plates 12, 12a. Each of the first plates 12, 12a has a first configuration. The two first plates 12, 12a can be identical. The two first plates 12, 12a are engaged in a back to back mirrored relationship to one another to form a first pair 14. The evaporator also includes two second plates 16, 16a, having a second configuration and engaged in a back to back mirrored relationship to one another to form a second pair 18. The first pair 14 of plates 12, 12a and the second pair 18 of plates 16, 16a are stacked together.

[0027] Referring now to Figures 2 and 6, each of the first plates 12, 12a can include a first peripheral lip 20, 20a extending along the periphery of the respective said first plate 12, 12a and a first center portion 22, 22a recessed with respect to the respective peripheral lip 20, 20a. The peripheral lips 20, 20a of the two first plates 12, 12a can engage one another when the pair 14 is formed. The center portions 22, 22a can be spaced apart from one another when the first pair 14 is formed, defining a first cavity 24 between the first plates 12, 12a.

[0028] Referring now to Figures 2, 10 and 11, each of the first plates 12, 12a can include first return apertures 26, 26a adjacent to the respective first center portions 22, 22a. The return apertures 26, 26a can communicate with the first cavity 24. Each of the two first plates 12, 12a can also include a first return trough 46, 46a recessed relative to the respective first center portion 22, 22a. The first return apertures 26, 26a can be individually disposed in respective bottoms 48, 48a of the first return troughs 46, 46a.

[0029] Referring now to Figures 2, 3, and 6-8, each of the first plates 12, 12a can include a first inlet aperture 28 and a first outlet aperture 30, 30a disposed on an opposite side of the respective first center portion 22, 22a relative to the respective first return aperture 26, 26a. Each of the first plates 12, 12a can also include a first inlet trough 58 recessed with respect to the respective first center portion 22, 22a. The first inlet aperture 28 can be disposed in a bottom 60 of the first inlet troughs 58. Each plate 12, 12a can also include a secondary inlet aperture 88. The secondary inlet 88 aperture can be

disposed in a bottom of an inlet trough 86. Referring now to Figures 14 and 15, an alternative embodiment of a first plate 12b can include a peripheral lip 20b, a center portion 22b, a return aperture 26b disposed at the bottom 48b of an inlet trough 46b, and a single inlet aperture 28b disposed at the bottom 60b of an inlet trough 58b.

[0030] Referring now to Figures 2, 3, 8, 9, 12 and 13, each of the first plates 12, 12a can include a first outlet trough 68, 68a recessed with respect to the respective first center portion 22, 22a. The first outlet apertures 30, 30a can be individually defined in respective bottoms 70, 70a of the first outlet troughs 68, 68a. Referring now to Figures 14 and 15, the alternative embodiment of a first plate 12b can include an outlet aperture 30b defined in a bottom 70b of an outlet trough 68b.

[0031] Referring now to Figures 2, 3 and 9, each of the first plates 12, 12a can include mounds 32, 32a projecting from the respective first center portions 22, 22a and surrounding the respective outlet apertures 30, 30a and/or the troughs 68, 68a. The mounds 32, 32a of the two first plates 12, 12a of the first pair 14 can engage one another when the first pair 14 is formed. The mounds 32, 32a can be in sealing engagement with one another to isolate the aligned outlet apertures 30, 30a from the first cavity 24. Referring now to Figures 14 and 15, the alternative embodiment of a first plate 12b can include a mound 32b surrounding the outlet aperture 30b. The mound 32b can surround the trough 68b.

[0032] The second plates 16, 16a can be substantially similar to the first plates 12, 12a. Referring now to Figures 4, 5, 6 and 7, each of the second plates 16, 16a can include a second peripheral lip 34, 34a extending along the respective peripheries of the second plates 16, 16a and second center portions 36, 36a recessed with respect to the respective peripheral lips 34, 34a. The peripheral lips 34, 34a of said two second plates 16, 16a can engage one another when the second pair 18 is formed. The second center portions 36, 36a can be spaced apart from one another when the second pair 18 is formed to define a second cavity 38 between the plates 16, 16a. Referring now to Figures

16 and 17, an alternative embodiment of the second plate 16b can include a second peripheral lip 34b extending along the periphery of the second plate 16b and a second center portion 36b recessed with respect to the second peripheral lip 34b.

[0033] Referring now to Figures 4, 5 and 10-13, each of the second plates 16, 16a can also include a second return aperture 40, 40a adjacent to the respective second center portion 36, 36a. The second return apertures 40, 40a, can communicate with the second cavity 38. Each of the two second plates 16, 16a can also include a second return trough 50, 50a recessed with respect to the respective second center portion 36, 36a. The second return apertures 40, 40a can be individually disposed in respective bottoms 52, 52a of the second return troughs 50, 50a. Referring now to Figure 16, the alternative embodiment of the second plate 16b can include a second return aperture 40b disposed at a bottom 52b of a return trough 50b.

[0034] Referring now to Figures 4-8, each of the second plates 16, 16a can include a second inlet aperture 42 and a second outlet aperture 44, 44a disposed on an opposite side of the respective second center portion 36, 36a relative to the second return apertures 40, 40a. Each plate 16, 16a can also include includes a second inlet trough 62 recessed with respect to the respective second center portion 36, 36a. The second inlet aperture 42 can be individually disposed in respective bottoms 64 of the second inlet trough 62. Each plate 16, 16a can also include a secondary inlet aperture 92. The secondary inlet aperture 92 can be disposed in a bottom of an inlet trough 90. Referring now to Figures 16 and 17, the alternative embodiment of the second plate 16b can include a single inlet aperture 42b disposed at a bottom 64b of an inlet trough 62b.

[0035] Referring now to Figures 4, 5, 8, 9, 12 and 13, each of the second plates 16, 16a can include a second outlet trough 72, 72a recessed with respect to the respective second center portion 36, 36a. The second outlet apertures 44, 44a can be individually disposed in respective bottoms 74, 74a of the second outlet troughs 72, 72a. Referring now to Figures 16 and 17, the

alternative embodiment of the plate 16b can include a second outlet aperture 44b disposed in a bottom 74b of a second outlet trough 72b.

[0036] Referring now to Figures 4, 5 and 7, each of the second plates 16, 16a can include a second mound 56 individually projecting from the respective second center portion 36, 36a and surrounding the respective second inlet aperture 42. The second plates 16, 16a also include a third mound 94 projecting from the respective second center portion 36, 36a and surrounding the secondary inlet aperture 92. As shown in the drawings, the mounds 56 and 94 can surround the troughs 62 and 90, respectively. When two second plates are engaged to form the pair 18, a mound 56 of the plate 16 is engaged with a mound 94a of the second plate 16a in response to the plates 16, 16a being in back-to-back, mirrored relation to one another. The engaged mounds 56, 94a can be in sealing engagement with one another to isolate the aligned apertures 42 and 92a from said second cavity (38). Mounds 56a, 94 can be in also be in sealing engagement with one another to isolate the aligned apertures 42a and 92 from said second cavity (38).

[0037] A plurality of pairs 14 and 18 of plates can be stacked together to form the evaporator 10. Referring now to Figures 10, 11, and 13, the bottom 48 of the first return trough 46 can cooperate in sealing engaging with the bottom 52a of the second return trough 50a when the pairs 14, 18 are stacked together. The return apertures 26, 26a, 40, 40a of the plates 12, 12a, 16, 16a can be aligned in response to stacking to define a return tank 54 in communication with the first and second cavities 24, 38. The return tank 54 can be in fluid communication with all of the cavities formed by the evaporator 10.

[0038] Referring now to Figures 8, 9 and 13, the bottom 70 of the first outlet trough 68 can cooperate in sealing engaging with the bottom 74a of the second outlet trough 72a between adjacent plates 12, 16a of the pairs 14, 18. The outlet apertures 30, 30a, 44, 44a of the plates 12, 12a, 16, 16a can be aligned in response to stacking to define a outlet manifold 76 in communication with only the second cavity 38 relative to the first and second cavities 24, 38.

[0039] Referring now to Figure 7, the bottom 60 of the inlet trough 58 can cooperate in sealing engaging with the bottom 98a of the inlet trough 90a between adjacent plates 12, 16a of adjacent pairs 14 and 18. The inlet apertures 28, 42, 88a, 92a of the plates 12, 12a, 16, 16a can be aligned in response to stacking to define an inlet manifold 66 in communication with only the first cavity 24 relative to the first and second cavities 24, 38. A similar, corresponding second inlet manifold 96 can be defined by aligned apertures on an opposite side of the outlet manifold 76.

[0040] Referring now to Figure 18, a plurality of pairs 14, 18 can be stacked in an alternating pattern. For example, a pair 18a can be positioned between first pair 14a and a third pair 78. The pair 78 can be identical to the pair 14a. Each pair 14, 14a, 18, 18a, 78 shown in the several Figures can define a cavity, such as cavities 24 and 38, between opposing plates 12, 12a, 12b, 12c, 12d, 16a, 16d. A fluid stream can be directed through the evaporator 10 be directed through the cavities defined by the various pairs 14, 14a, 18, 18a, 78 of opposing plates 12, 12a, 12b, 12c, 12d, 16a, 16d. Fluid streams can be directed in opposite directions along the height of the stack of the evaporator 10. For example, a first fluid stream 80 can move in a first direction. A second fluid stream 82 can move in a second direction. A third fluid stream 84 can move in the first direction. The second fluid stream 82 can be disposed between the first and third fluid streams 80, 84.

[0041] In operation, a stream of fluid to be evaporated can be directed into inlet manifolds 66, 96 of the evaporator 10. The stream can be divided into sub-streams; each sub-stream passing from the inlet manifolds 66, 96 to cavities 24 defined between first plates 12, 12a disposed in back-to-back mirrored relationship with one another. The sub-streams can be rejoined at the return tank 54 and re-divided to move into cavities 38 defined between second plates 16, 16a disposed in back-to-back mirrored relationship with one another. The sub-streams can be rejoined in the outlet manifold 76 and the fluid stream can evacuate the evaporator 10.

[0042] The exemplary embodiment of the invention provides numerous advantages over the prior art. For example, the invention provides Improved Temperature Uniformity of Evaporator Discharge Air. Automotive evaporators operate such that they are not completely "flooded" with refrigerant. This means that somewhere toward the end of the refrigerant flow path, the refrigerant is completely evaporated. From this "dry point" to the outlet of the evaporator exists a region where the refrigerant is superheated. This superheated region of the evaporator becomes an area that that doesn't much cool the air flowing through it and thus results in a "hot spot" at air discharge face of the evaporator. Further, in recent years, automotive trend is away from Orifice Tube expansion devices toward Thermal Expansion Valves, which results in higher levels of superheat, thus aggravating the temperature uniformity issue. This invention, through it's alternating refrigerant flow arrangement, isolates these "hot spots" to a number of smaller areas instead of one bigger area, each surrounded by cold, flooded (inlet) evaporator tubes so that the resulting mixed air at the evaporator outlet is not so hot.

[0043] Furthermore, the invention provides improved Cooling Capacity. With this invention, each particle of refrigerant makes only two passes through the evaporator vs. the more typical four or more passes on conventional evaporators. This should lower the refrigerant side pressure drop. And, since in the evaporator, refrigerant exists in the 2-phase state (except for superheated region), and since, the refrigerant temperature depends directly on the refrigerant pressure in the 2-phase state, this lower pressure drop directly affects the temperature of the refrigerant and thus it's capacity to cool and dehumidify the air. To explain further, since the pressure at the outlet of the evaporator is more or less fixed by the refrigerant controls to keep the evaporator from getting too cold and "freezing up", the lower pressure drop evaporator keeps the evaporator at a lower "mean evaporating temperature and pressure" therefore enhancing Cooling Capacity. There is another feature of this invention that similarly can enhance Cooling Capacity. Typical evaporators have identical individual refrigerant flow passages (tubes) in the evaporator.

But since the refrigerant is evaporating, and thus increasing it's volumetric flow rate, as it flows through the evaporator, the ideal situation is to have an increasing area in the refrigerant flow direction—to reduce pressure drop. Since in this invention, the alternating passages can be different—one internal tube height for "inlet" tubes and another, larger, for "outlet" tubes—this feature also can reduce the refrigerant side pressure drop and enhance Cooling Capacity. Conventional evaporators accomplish this by varying the number of individual tubes in each refrigerant pass, a different technique than the feature of the invention just described.

[0044] Furthermore, the invention provides improved Noise characteristics. It is well known that if air side pressure drop can be reduced, then noise can be reduced since fan power is reduced. One way air side pressure drop can be reduced, for any given evaporator size (exterior dimensions) is to increase the proportion of the face area open to the air flow. This invention can enhance this is two ways. The first is that, the smaller return manifold mentioned above that this alternating flow idea allows, means that less of the total face area normal to the flow of the air is blocked, allowing reduction in pressure drop. The second is that since, as mentioned above, the inlet tubes can be made smaller in height than the outlet tubes this smaller tube height creates less blockage to the air flow (in this case the invention allows the choice of also reducing air side pressure drop instead of refrigerant pressure drop or in any combination that optimizes the two for any specific application).

[0045] Furthermore, the invention provides improved environmental characteristics. It has already been mentioned above that air side and refrigerant side pressure drop can be reduced with this invention. This also reduces power consumption and thus increases the efficiency of the air conditioning unit. Additionally, however, the ability to decrease the height of the refrigerant tubes can reduce the internal volume (refrigerant side volume) of the evaporator, thus allowing a modest reduction in the "charge" of refrigerant required for the vehicle air conditioning unit. This is a mass savings for the

vehicle, and further, could be advantageous if the usage of refrigerant were to some day be limited due to environmental issues.

[0046] Furthermore, the exemplary embodiment of this invention is of simple construction. The tube plates can be die struck and these tube plates form the manifolds and even can form the refrigerant control orifices in the manifolds, if needed. Contrast this with the recently introduced compact evaporators that have good temperature uniformity. These have two rows of extruded tubes, separate manifolds that are not common, and even have separate orifice pieces that must be placed in the manifolds. The potential refrigerant charge reduction mentioned above is also a direct cost reduction.

[0047] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.